

## PATENT ABSTRACTS OF JAPAN

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(71)Applicant : SHOWA ALUM CORP

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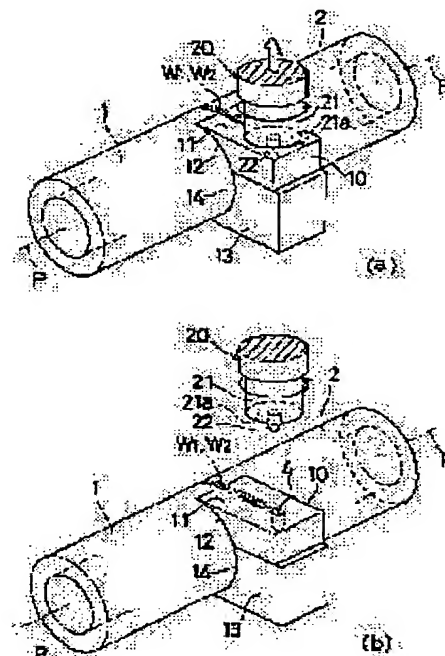
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## (54) FRICTION STIRRING JOINING METHOD

## (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a friction stirring joining method that causes no holes or recesses after a probe is pulled out, in joining members having parts to be welded in the peripheral direction on the circumferential surface.

**SOLUTION:** The end faces are abutted on each other of the two joining members 1, 2 that consist of an aluminum pipe material having a circular cross section, with a rotating probe 22 inserted into this abutted part. Then, while the part in contact with the probe 22 is softened by frictional heat and stirred, the joining members 1, 2 are rotated so that the abutted part successively passes through the probe 22. When the joining members 1, 2 make one rotation, they are stopped. After that, an abutting member 10 is applied against the joining end W2 in the tangential direction of the seam in this joining end. Then, the probe 22 is moved to the abutting member 10.



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CLAIMS

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## [Claim(s)]

[Claim 1] Inserting the rotating probe (22) in the aforementioned joint (3) in the joint material (1) which has the joint (3) of a hoop direction in a peripheral surface, and (2), softening the contact section with a probe in frictional heat, and agitating By moving a probe (22) relatively along with the aforementioned joint (3) in the state of insertion In the friction churning conjugation method which joins the aforementioned joint material (1) and (2) to the junction trailer (W 2) of the aforementioned joint material The friction churning conjugation method characterized by guessing in the tangential direction of the junction line in this junction trailer, or the direction near it, applying a member (10), making it pass and moving the probe (22) of the aforementioned insertion state for a junction trailer (W 2) to a reliance member (10).

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## DETAILED DESCRIPTION

## [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the friction churning conjugation method which joins the peripheral surface of the joint material which has a circular cross section or a polygon cross section to a hoop direction, if the friction churning conjugation method used for junction of metal material, such as for example, aluminum material (aluminium alloy material is included), is explained in full detail.

[0002]

[Description of the Prior Art] For example, as shown in drawing 8 (a), when comparing the end faces of the joint material (51) which consists of two metallic-pipe material which has a circular cross section, and (52), comparing both [ these ] joint material (51) and (52) and continuing and joining to the perimeter of the section (53), the friction churning conjugation method which is one of the solid phase conjugation methods may be used.

[0003] It will be as follows if this friction churning conjugation method is explained. That is, the aforementioned probe (62) is inserted in the matching section (53) of both joint material (51) and (52) from the peripheral face, rotating the aforementioned rotator (61) using the junction tool (60) which the pin-like probe (62) of \*\*\*\* projected and was formed on the edge axis of the pillar-like rotator (61) of path size at one, as shown in this drawing. Generally, insertion is performed until the shoulder (61a) which consists of a probe side flat side of a rotator (61) contacts both joint material (51) and (52).

[0004] And with a probe insertion state, as shown in drawing 8 (b), both joint material (51) and (52) are rotated focusing on the axis (Q) so that the matching section (53) may pass a probe (62) one by one. Or although not illustrated, a probe (62) may be compared in the state of insertion, and may be moved to the hoop direction of both joint material (51) and (52) along with the section (53). With the frictional heat generated by rotation of a probe (62), or the frictional heat further generated with the shoulder (61a) of a rotator (61), and sliding with both joint material (51) and (52) While softening both joint material (51) and (52) [ near the contact portion with a probe (62) ] and being agitated by the probe (62) After carrying out a plastic flow with movement of a probe (62) with rotation of both joint material (51) and (52) so that a softening churning portion may fill the passage slot on the probe (62), frictional heat is lost quickly and cooling solidification is carried out. This phenomenon is successively repeated with movement of a probe (62) with rotation of both joint material (51) and (52), and finally both joint material (51) and (52) compare, and it is joined in the section (53). In this drawing, (X) is the junction bead section formed of this friction churning junction, and is formed along with the matching section (53). Moreover, (X1) is a junction leader.

[0005] According to such a friction churning conjugation method, since it is solid state welding, it is not limited to the kind of metal material which is joint material, or there is an advantage, like there is little deformation by the heat distortion at the time of junction.

[0006] By the way, if a junction leader (X1) returns to the insertion point of a probe (62) when carrying out friction churning junction of the above-mentioned joint material (51) and (52), since it is not necessary to join any more, after stopping rotation of joint material (51) and (52), as it \*\* to drawing 9 , you have to draw out a probe (62) from joint material (51) and (52).

[0007]

[Problem(s) to be Solved by the Invention] However, if a probe (62) is drawn out from the peripheral face of joint material (51) and (52) to shaft orientations, the hole (54) corresponding to the path of a probe (62) and the immersion depth will surely remain in a junction trailer (X2). Since this hole (54) is that to which a bonding strength is reduced locally, it must remove or bury this after a junction end.

[0008] this hole — the method of filling up a hole (54) with molten metal as a processing means by melting welding of the method of embedding a pin at a hole (54), TIG, MIG, etc., etc. is proposed However, since the method embedding a pin only fixes a pin by mechanical penetrating, it is deficient in reliability on the strength. Moreover, the method by melting welding has problems, like the fall of a bonding strength and heat distortion arise with the welding heat generated at the time of welding.

[0009] In addition, although not illustrated, when carrying out friction churning junction of the joint material which consists of a joint from which a junction trailer does not return to a leader, for example, the plate which has a straight-line-like joint on a front face, a weld tab is attached in the direction of a junction line at the junction trailer in the end face of joint material, and the method of drawing out this probe from a weld tab, after moving a probe (62) to a weld tab, and subsequently removing this weld tab is effective.

[0010] However, since the anchoring place of a weld tab does not exist in joint material in applying to the circumferential junction performed in accordance with the peripheral surface of the joint material which has circular cross sections and polygon cross sections, such as periphery junction which was described above, this method cannot apply this.

[0011] Drawing out the probe (62) of an insertion state from the other end side of joint material (51) and (52), when joining the above-mentioned joint material (51) and (52) moreover, idea \*\* In this case, since a crevice (not shown) will be formed in the other end side of joint material (51) and (52) as drawing marks of a probe, the problem that the appearance of the junction article obtained becomes bad arises.

[0012] This invention was made in order to solve such a problem, and it aims at offering the friction churning conjugation method

which does not produce the hole or crevice after probe drawing in the friction churning conjugation method which joins the joint material which has the joint of a hoop direction in a peripheral surface.

[0013]

[Means for Solving the Problem] This invention inserting the rotating probe in the aforementioned joint in the joint material which has the joint of a hoop direction in a peripheral surface, softening the contact section with a probe in frictional heat, and agitating, in order to attain the above-mentioned purpose By moving a probe relatively along with the aforementioned joint in the state of insertion In the friction churning conjugation method which joins the aforementioned joint material, it is characterized by guessing in the tangential direction of the junction line in this junction trailer, or the direction near it, applying a member, making the junction trailer of the aforementioned joint material pass a junction trailer, and making it move the probe of the aforementioned insertion state to a reliance member.

[0014] According to this, by guessing in the tangential direction of the junction line in this junction trailer, or the direction near it, and applying a member to the junction trailer of joint material, the probe of an insertion state can be applied with an insertion state, and can be moved now to a member. And if a probe guesses and it advances into a member, the amount of [ with the probe in a reliance member ] contact softened zone will carry out a plastic flow to back, and the slot produced after passage of a probe will be filled. Subsequently, the probe of an insertion state which moved to the reliance member is applied, and it draws out from a member. By carrying out like this, it becomes impossible for the hole and crevice after probe drawing to remain in a joint therefore, the fall of the bonding strength of a joint can be prevented, and the reliability of a joint on the strength also improves. Then, further, by removing a reliance member, the fall of the appearance appearance of the junction article which the hole and crevice after probe drawing stop remaining in joint material therefore, and is produced by the hole and crevice after probe drawing can be prevented, therefore the appearance of a junction article can be maintained now.

[0015]

[Embodiments of the Invention] Next, the operation gestalt of this invention is explained based on a drawing.

[0016] Drawing 1 - drawing 6 show 1 operation gestalt of this invention. In drawing 1, (1) and (2) are two joint material which consists of cylindrical aluminum extrusion pipe material which has predetermined length in a circular cross section. These joint material (1) and (2) are isomorphism and this \*\* mutually. And these joint material (1) and (2) are arranged in the mode which compares end faces. In this matching state, the axis (P) of these joint material (1) and (2) and (P) are in agreement, therefore the peripheral face of one joint material (1) and its peripheral face of the joint material (2) of another side are flat-tapped.

[0017] this operation gestalt shows the case where cover the perimeter of the matching section (3) and friction churning junction of two joint material (1) arranged in the matching state and (2) is carried out as well as the above-mentioned conventional technology — it is a thing Therefore, the matching section (3) turns into a joint of joint material (1) and (2), and the hoop direction in the matching section (3) of joint material (1) and (2) turns into the direction of a junction line. And the junction article joined by this friction churning junction is used as the member for suspension arms, the member for engine mounts, a member for space frames, etc.

[0018] (20) is a junction tool, on the edge axis of the pillar-like rotator (21) of path size, the pin-like probe (22) of \*\*\*\* projects, it is prepared at one, and high-speed rotation of the probe (22) is carried out by carrying out high-speed rotation of the rotator (21). In addition, the probe (22) and the rotator (21) are formed with the heat-resisting material which can bear the frictional heat which is hard and is generated from joint material (1) and (2) at the time of junction.

[0019] (10) — the reliance made from aluminum of a tabular — it is a member This reliance member (10) is for a probe (22) drawing out to the junction trailer of joint material (1) and (2), and making [ do not leave a hole or a crevice and ] them it so that it may mention later. It is hit against the tangential direction of the junction line in this junction trailer by the junction trailer, one side of the thickness direction is made into a probe passage side (11), and the end side of the length direction is made into a contact side (12) with joint material. While the aforementioned probe passage side (11) consists of a flat side, the aforementioned contact side (12) consists of a curve side which curved circularly so that it might correspond to the peripheral face of joint material (1) and (2). When this reliance member (10) applies this to a junction trailer (W2) at the tangential direction of the junction line in this junction trailer, and (refer to drawing 4 (a)), While the aforementioned contact side (12) contacts the peripheral face of joint material (1) and (2) at a field contact state, the aforementioned probe passage side (11) has become flat-tapped with the peripheral face of the joint material (1) in a junction trailer (W2), and (2).

[0020] And this reliance member (10) is supported with sufficient stability by the metal supporter material (13) of the letter of a block. This supporter material (13) is applied by the peripheral face of joint material (1) and (2) with a reliance member (10), and the contact side (14) consists of a curve side which curved circularly so that it might correspond to the peripheral face of joint material (1) and (2). And when this supporter material (13) applies the aforementioned reliance member (10) to a junction trailer (W2), the aforementioned contact side (14) is contacted by the peripheral face of joint material (1) and (2) at the field contact state. Friction churning junction according to this invention is performed as follows. That is, the probe (22) of the rotation state of the aforementioned junction tool (20) is inserted in the matching section (3) from the front face, as shown in drawing 1 and drawing 2 (a). As shown in drawing 2 (b), in the state of probe insertion and the flatness-like shoulder (21a) at the nose of cam of a rotator (21) While making the peripheral face of joint material (1) and (2) contact can prevent scattering of the material for a softened zone in the middle of the time of a junction start, or junction and it can realize a uniform junction state It is desirable from the point of making frictional heat produce further by sliding with joint material (1), (2), and a shoulder (21a), promoting the contact section with a probe, or softening of the near, and preventing concavo-convex formation of the peripheral face of joint material (1) and (2) further.

[0021] And with a probe insertion state, the axis (P) is rotated for joint material (1) and (2) as the axis of rotation so that the matching section (3) may pass a probe (22) one by one.

[0022] With the frictional heat generated by rotation of a probe (22), or the frictional heat further generated with sliding with the shoulder (21a) of a rotator (21), and the peripheral face of joint material (1) and (2) After carrying out a plastic flow with rotation of joint material (1) and (2) so that a softening churning portion may fill the passage slot on the probe (22) while softening joint material (1) and (2) [ near the contact portion with a probe (22) ] and being agitated, frictional heat is lost quickly and cooling solidification is carried out. As this phenomenon is successively repeated with rotation of joint material (1) and (2) and it is

shown in drawing 3 (a), in the matching section (3), it is unified and both joint material (1) and (2) are joined one by one. In addition, in drawing 3 (a), (W) is the junction bead section formed of this friction churning junction, and is formed along with the matching section (3). Moreover, (W1) is a junction leader.

[0023] And when the junction leader (W1) has returned to the insertion point of a probe (22), Or when a junction leader (W1) passes the insertion point of a probe (22) further, That is, although it becomes a junction end since it means that both joint material (1) and (2) were continued and joined to the perimeter of the matching section (3) as shown in drawing 3 (b) when joint material (1) and (2) rotate, [ one or more-revolution ] when the probe (22) was drawn out from the peripheral face of joint material (1) and (2) by this probe insertion point, the above-mentioned conventional technology explained — as — a junction trailer (W2) — drawing of a probe — a hole will arise

[0024] Then, after stopping rotation of joint material (1) and (2), a member (10) is applied at the tangential direction of the junction [ in / this junction trailer (W2) / as shown in drawing 4 (a) by guessing / to a junction trailer (W2) ] line supported by supporter material (13). In this way, in the state where guessed and the member (10) was applied to the junction trailer (W2), the probe passage side (11) of a reliance member (10) is as flat-tapped as the peripheral face of the joint material (1) in a junction trailer (W2), and (2). In addition, although not illustrated, before joint material (1) and (2) rotate one time, you may apply a reliance member (10) beforehand.

[0025] Subsequently, the probe (22) of an insertion state is applied and it is made to move to a member (10), as shown in drawing 4 (b). On the occasion of movement of this probe, with the peripheral face of the joint material (1) in a junction trailer (W2), and (2), since the probe passage side (11) of a reliance member (10) is flat-tapped, it can move a probe (22) to a reliance member (10) smoothly with an insertion state.

[0026] Thus, if a probe (22) guesses and it advances into a member (10), the amount of [ with the probe (22) in a reliance member (10) ] contact softened zone carries out a plastic flow to back, and the slot produced after passage of a probe (22) is filled, therefore neither a hole nor a crevice remains in the junction trailer (W2) of joint material (1) and (2).

[0027] Subsequently, the probe (22) which moved to the reliance member (10) is drawn out from the probe passage side (11) of a reliance member (10), as shown in drawing 5. then, a reliance member (10) — drawing of a probe — since a hole (4) will be formed, as shown in drawing 6, along with the peripheral face of joint material (1) and (2), cutting removal of this reliance member (10) is carried out By carrying out like this, it becomes impossible for a hole and a crevice to remain on the remains of probe passage in joint material (1) and (2) therefore, and a junction state can obtain a good junction article.

[0028] In addition, although not illustrated, the probe (22) which moved to the reliance member (10) may be applied, it may draw out from the end face of a member (10), and, subsequently this reliance member (10) may be removed.

[0029] Moreover, you may carry out separately the process which joins the matching section (3) of joint material (1) and (2), and the process which applies a probe (22) and is moved to a member (10). Namely, after joining the matching section (3) of joint material (1) and (2), for example, by drawing out a probe (22) from joint material (1) and (2) a junction trailer (W2) — drawing of a probe, while manufacturing beforehand two or more junction articles with which the hole (4) is formed, hitting against the junction trailer (W2) of a junction article after that and applying a member (10) probe drawing — a probe may be again inserted in a hole (4), this probe may be applied, and you may make it move to a member (10)

[0030] In addition, as mentioned above, as for the thing and bird clapper which the remains of probe passage of the junction trailer in joint material (1) and (2) are filled up with a part of material of a reliance member (10), and make a part of joint material to a reliance member (10), it is desirable to be manufactured by the same material as joint material (1) and (2).

[0031] Drawing 7 shows the example of a changed completely type of the above-mentioned operation form.

[0032] This modification shows the case where the butt joint of two or more joint material is carried out continuously. It will be as follows if this friction churning conjugation method is explained.

[0033] That is, as shown in this drawing (i), the probe (22) of a junction tool (20) is inserted in the matching section (3) of joint material (1) and (2) like the above-mentioned operation form. And when joint material (1) and (2) rotate, this joint material (1) and (2) compare and it is continued and joined to the perimeter of the section (3). [ one or more-revolution ] After stopping rotation of joint material (1) and (2), while applying the end section of a reliance member (10) to a junction trailer (W2), the other end is applied to the matching section (3') of the joint material in the state where it does not join (1') (2'). Subsequently, the probe (22) of an insertion state is applied and it is made to move to a member (10), as shown in this drawing (ii). Furthermore, a probe (22) is moved and this probe (22) is made to advance into the matching section (3') of the joint material in the state where it does not join (1') (2'), as shown in this drawing (iii). Subsequently, after cutting a reliance member (10) along with the peripheral face of the joint material in the state where it does not join (1') (2') (cutting section 10a), as shown in this drawing (i), friction churning junction of the matching section (3') of the joint material in this state where it does not join (1') (2') is carried out like the above-mentioned operation form.

[0034] By carrying out like this, the butt joint of two or more joint material can be continuously carried out now, the hole or crevice after probe drawing do not remain, that is, the good junction article of a junction state can be obtained efficiently.

[0035] Furthermore, this invention is not limited to the above-mentioned operation form.

[0036] For example, joint material (1) and (2) are not rotated, joint material (1) and (2) are fixed, and a probe (22) may be moved along with the matching section (3) of joint material (1) and (2).

[0037] Moreover, the direction which applies a reliance member (10) to a junction trailer (W2) may be a direction near the tangential direction of the junction line in a junction trailer (W2).

[0038] From the first, joint material (1) and (2) may not consist of metal material other than aluminum, they do not need to be pipe material, and may be solid material.

[0039]

[Effect of the Invention] This invention inserting the rotating probe in the aforementioned joint in the joint material which has the joint of a hoop direction in a peripheral surface, softening the contact section with a probe in frictional heat, and agitating by above-mentioned order By moving a probe relatively along with the aforementioned joint in the state of insertion In the friction churning conjugation method which joins the aforementioned joint material to the junction trailer of the aforementioned joint material Guess in the tangential direction of the junction line in this junction trailer, or the direction near it, and a member is

applied. Since it is characterized by passing a junction trailer and moving the probe of the aforementioned insertion state to a reliance member, according to the friction churning conjugation method concerning this invention, by part for a contact softened zone with the probe in a reliance member, the slot produced after passage of a probe is filled and things are made. Therefore, even if it is the case where the joint material which has the joint of a hoop direction in a peripheral surface is joined by friction churning junction, the hole or crevice after probe drawing cannot remain in a junction trailer, that is, the bonding strength of a joint can obtain a high junction article with the high reliability on the strength to it. Furthermore, after drawing out a probe from a reliance member, by removing this reliance member, the hole or crevice after probe drawing cannot remain in joint material, that is, the good junction article of appearance can be obtained to it.

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DESCRIPTION OF DRAWINGS

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## [Brief Description of the Drawings]

[Drawing 1] It is the perspective diagram showing 1 operation form of this invention.

[Drawing 2] It is drawing showing this operation form, and is a cross section in the state where (a) inserted the probe in the II-II line cross section in drawing 1 , and (b) inserted it in the matching section of joint material.

[Drawing 3] It is drawing showing this operation form, and is a cross section in the state where the cross section of the state in the middle of rotation of joint material rotated (a), and joint material rotated (b) one time.

[Drawing 4] It is drawing showing this operation gestalt, and they are a cross section in the state where (a) applied the reliance member to the junction trailer, and a cross section in the state where (b) applied the probe and it was made to move to a member.

[Drawing 5] It is drawing showing this operation gestalt, and they are a perspective diagram in the state where (a) applied the probe and it was made to move to a member, and a perspective diagram in the state where (b) applied the probe and it drew out from the member.

[Drawing 6] It is drawing showing this operation gestalt, and is a perspective diagram in the state where the reliance member was detached from joint material.

[Drawing 7] It is drawing showing the example of a changed completely type of this operation gestalt, and they are a cross section in the state where (i) applied the cross section of the state in the middle of rotation of joint material, (ii) applied the probe, and it was made to move to a member, and a cross section in the state where (iii) detached the reliance member from non-joined joint material.

[Drawing 8] It is drawing showing the conventional friction churning junction, and (a) is the perspective diagram of the state before junction of joint material, and (b) is the perspective diagram of the state in the middle of junction.

[Drawing 9] It is drawing showing the fault of the conventional friction churning junction, and is the perspective diagram of the state after junction of joint material.

## [Description of Notations]

- 1 2 — Joint material
  - 3 — Matching section (joint)
  - 4 — probe drawing — a hole
  - 10 — It guesses and is a member.
  - 13 — Supporter material
  - 20 — Junction tool
  - 22 — Probe
  - W — Junction bead section
  - W1 — Junction leader
  - W2 — Junction trailer
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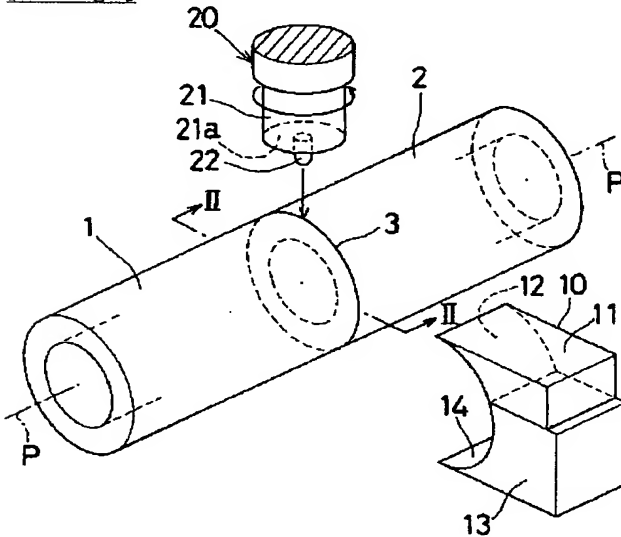
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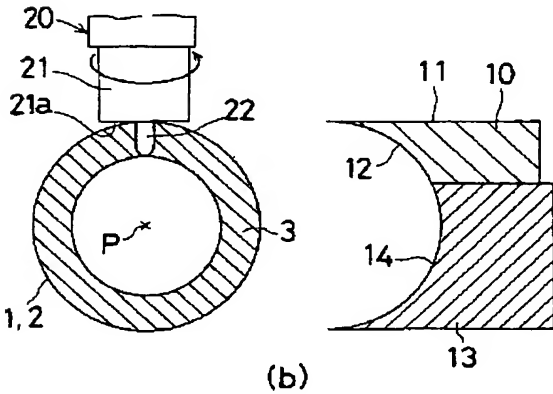
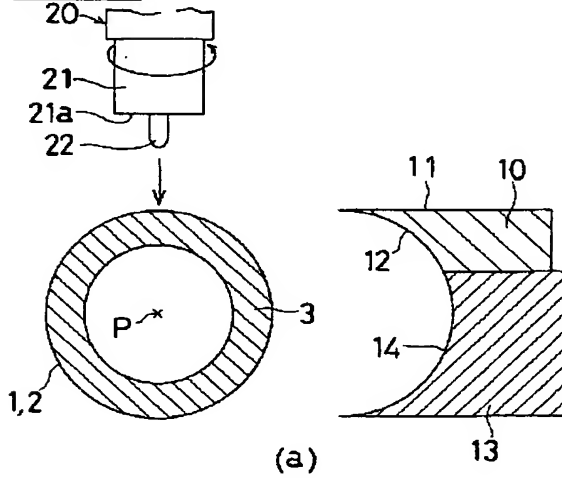
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## DRAWINGS

[Drawing 1]

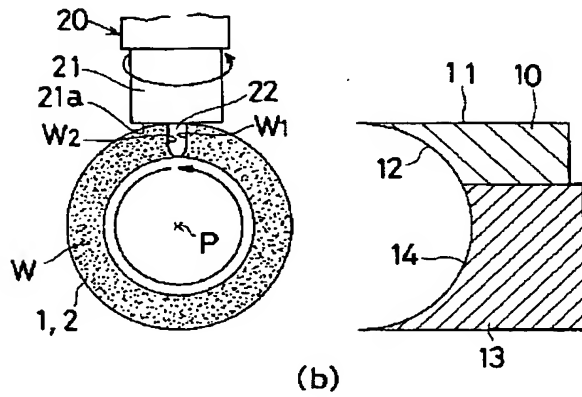
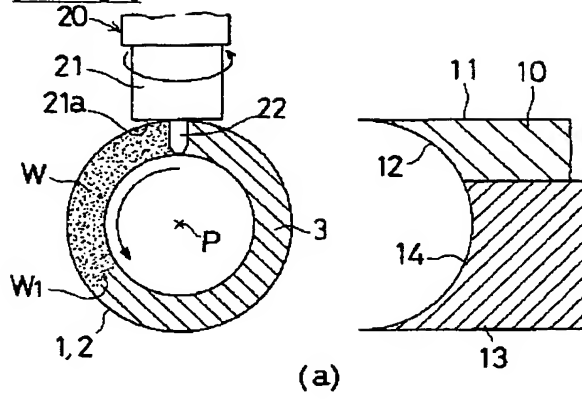


[Drawing 2]

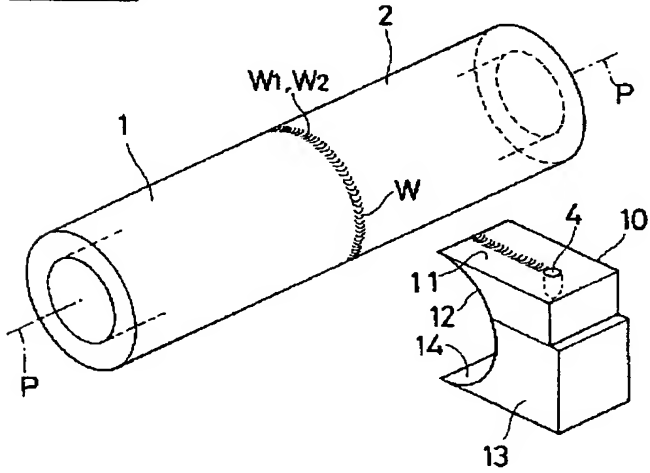




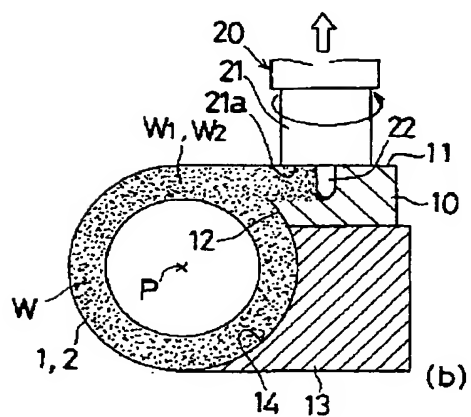
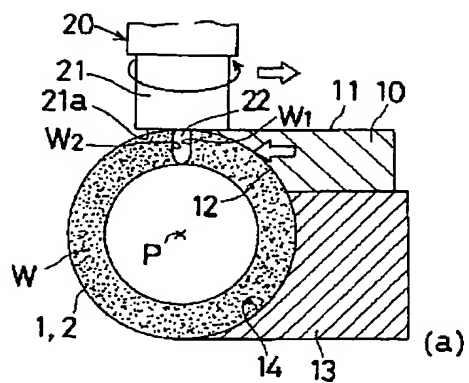
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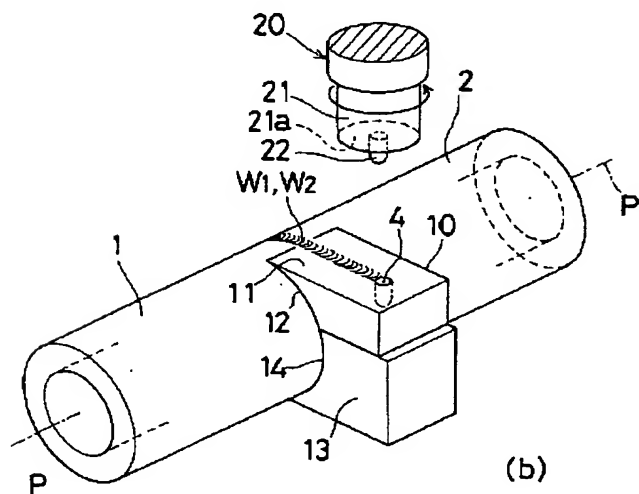
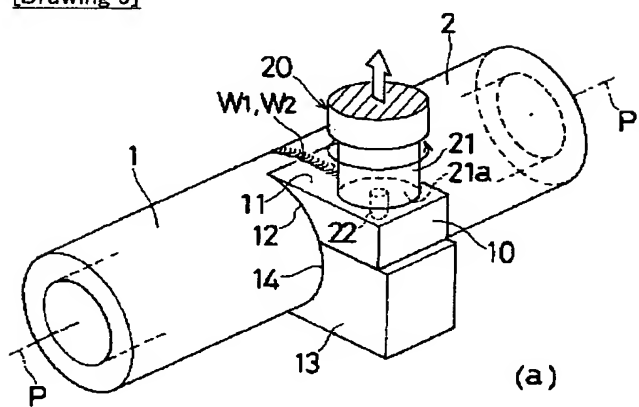
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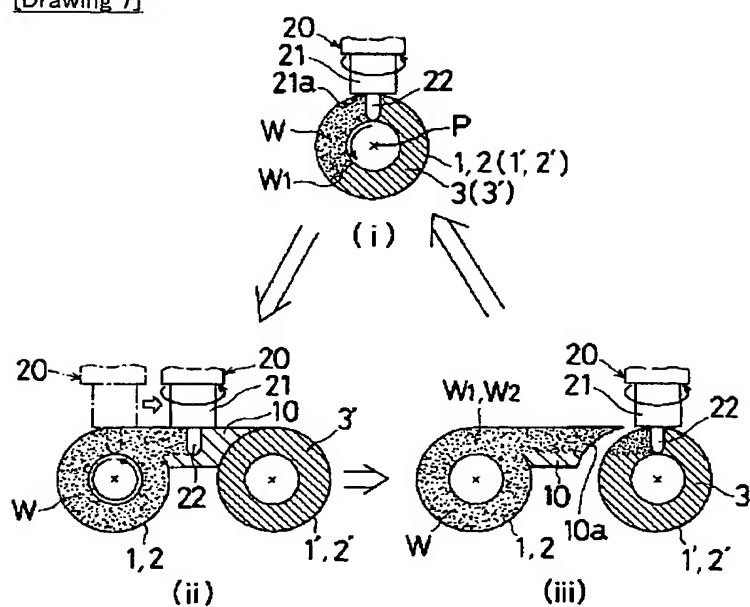
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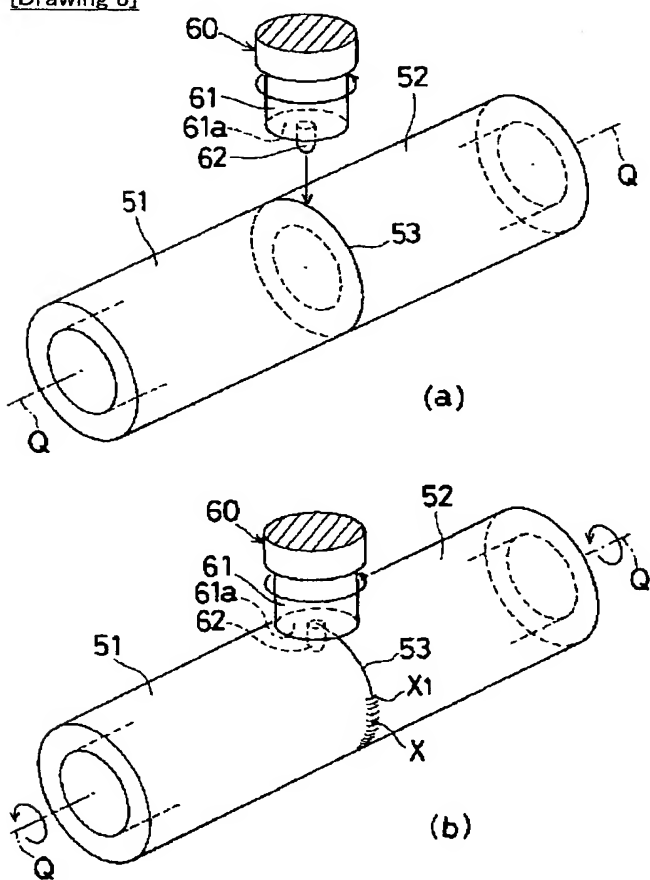
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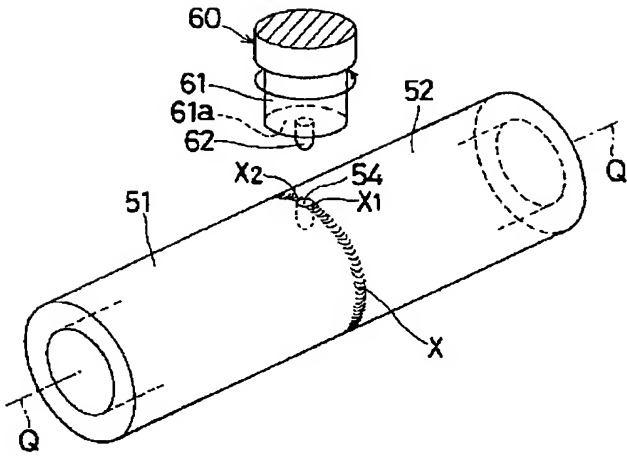
[Drawing 7]



[Drawing 8]



[Drawing 9]



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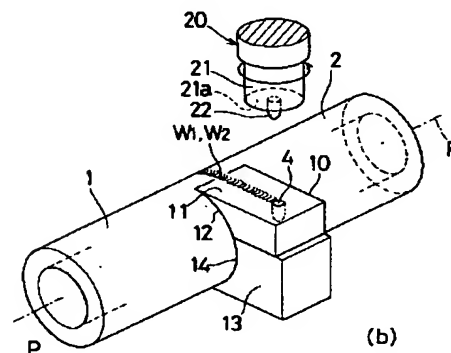
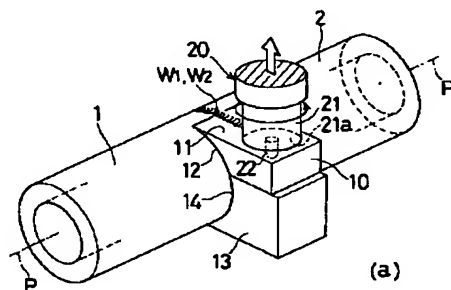
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## (54) 【発明の名称】 摩擦撹拌接合法

## (57) 【要約】

【課題】 周面に周方向の接合部を有する接合部材を接合する摩擦撹拌接合法において、プローブ引抜き後の孔や凹部を生じさせない摩擦撹拌接合法を提供すること。

【解決手段】 円形断面のアルミニウム製パイプ材からなる2個の接合部材1、2の端面同士を突き合わせ、この突合せ部3に回転するプローブ22を挿入する。そして、プローブ22との接触部を摩擦熱にて軟化させ撹拌しながら、突合せ部3がプローブ22を順次通過するように接合部材1、2を回転させる。接合部材1、2が1回転したら、接合部材1、2の回転を停止する。そして、接合終端部W2に、この接合終端部における接合線の接線方向に、当て部材10を当てる。次いで、プローブ22を当て部材10に移動させる。



## 【特許請求の範囲】

【請求項 1】 周面に周方向の接合部（3）を有する接合部材（1）（2）における前記接合部（3）に、回転するプローブ（22）を挿入し、プローブとの接触部を摩擦熱にて軟化させ攪拌しながら、プローブ（22）を挿入状態で前記接合部（3）に沿って相対的に移動させることにより、前記接合部材（1）（2）を接合する摩擦攪拌接合法において、

前記接合部材の接合終端部（W 2）に、該接合終端部における接合線の接線方向又はそれに近い方向に当て部材（10）を当て、前記挿入状態のプローブ（22）を、接合終端部（W 2）を通過させ当て部材（10）へと移動させることを特徴とする摩擦攪拌接合法。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】この発明は、例えばアルミニウム材（アルミニウム合金材を含む）等の金属材の接合に用いられる摩擦攪拌接合法に関し、詳述すれば、円形断面又は多角形断面を有する接合部材の周面を周方向に接合する摩擦攪拌接合法に関する。

## 【0002】

【従来の技術】例えば、図 8（a）に示すように、円形断面を有する 2 個の金属パイプ材からなる接合部材（5 1）（5 2）の端面同士を突き合わせ、これら両接合部材（5 1）（5 2）を突合せ部（5 3）の全周に亘って接合する場合には、固相接合法の一つである摩擦攪拌接合法が用いられることがある。

【0003】この摩擦攪拌接合法を説明すれば、次の通りである。即ち、同図に示すように、径大の円柱状回転子（6 1）の端部軸線上に径小のピン状プローブ（6 2）が突出して一体に設けられた接合工具（6 0）を用い、前記回転子（6 1）を回転させつつ、両接合部材（5 1）（5 2）の突合せ部（5 3）にその外周面から前記プローブ（6 2）を挿入する。挿入は、一般には、回転子（6 1）のプローブ側平坦面からなる肩部（6 1 a）が両接合部材（5 1）（5 2）に当接するまで行う。

【0004】そして、図 8（b）に示すように、プローブ挿入状態のまま、突合せ部（5 3）がプローブ（6 2）を順次通過するように両接合部材（5 1）（5 2）をその軸線（Q）を中心にして回転させる。あるいは、図示していないが、プローブ（6 2）を挿入状態で突合せ部（5 3）に沿って両接合部材（5 1）（5 2）の周方向に移動させても良い。プローブ（6 2）の回転により発生する摩擦熱、あるいは更に回転子（6 1）の肩部（6 1 a）と両接合部材（5 1）（5 2）との摺動に伴い発生する摩擦熱により、プローブ（6 2）との接触部分近傍において両接合部材（5 1）（5 2）は軟化しかつプローブ（6 2）により攪拌されるとともに、両接合部材（5 1）（5 2）の回転に伴って、あるいはプロー

ブ（6 2）の移動に伴って、軟化攪拌部分がプローブ

（6 2）の通過溝を埋めるように塑性流動したのち摩擦熱を急速に失って冷却固化される。この現象が両接合部材（5 1）（5 2）の回転に伴って、あるいはプローブ（6 2）の移動に伴って順次繰り返されていき、最終的に両接合部材（5 1）（5 2）が突合せ部（5 3）において接合されるものである。同図において、（X）はこの摩擦攪拌接合によって形成された接合ビード部で、突合せ部（5 3）に沿って形成されている。また、（X 1）は接合始端部である。

【0005】このような摩擦攪拌接合法によれば、固相接合であるため、接合部材である金属材の種類に限定されないとか、接合時の熱歪みによる変形が少ない等の利点がある。

【0006】ところで、上記の接合部材（5 1）（5 2）を摩擦攪拌接合する場合において、接合始端部（X 1）がプローブ（6 2）の挿入位置に戻ると、それ以上接合する必要があるから、接合部材（5 1）（5 2）の回転を停止した後、図 9 に示すように、プローブ（6 2）を接合部材（5 1）（5 2）から引き抜かなければならない。

## 【0007】

【発明が解決しようとする課題】しかしながら、プローブ（6 2）を接合部材（5 1）（5 2）の外周面から軸方向に引き抜くと、接合終端部（X 2）には、必ずプローブ（6 2）の径、挿入深さに対応する孔（5 4）が残ってしまう。この孔（5 4）は接合強度を局部的に低下させるものであるため、接合終了後に、これを取り除いたり、埋めたりしなければならない。

【0008】この孔処理手段として、孔（5 4）にピンを埋め込む方法や、TIG、MIG 等の溶融溶接により孔（5 4）に溶融金属を充填する方法が提案されている。しかし、ピンを埋め込む方法は、ピンを機械的な食込みにより固定するだけなので、強度的信頼性が乏しい。また、溶融溶接による方法は、溶接時に発生する溶接熱により接合強度の低下や熱歪みが生じる等の問題がある。

【0009】その他、図示していないが、接合終端部が始端部に戻らないような接合部、例えば表面に直線状の接合部を有する板材からなる接合部材を摩擦攪拌接合する場合には、接合部材の端面における接合終端部にエンドタブを接合線方向に取り付け、そしてプローブ（6 2）をエンドタブまで移動させた後、該プローブをエンドタブから引き抜き、次いでこのエンドタブを取り除く方法が有効である。

【0010】しかしながら、この方法は、上記したような円周接合等、円形断面や多角形断面を有する接合部材の周面に沿って行う周接合に適用する場合には、接合部材にエンドタブの取付け場所が存在しないので、これを適用することができない。

【0011】また、上記の接合部材(51)(52)を接合する場合において、挿入状態のプロープ(62)を接合部材(51)(52)の他端面から引き抜くことも考えられ、この場合には、接合部材(51)(52)の他端面にプロープの引抜き痕として凹部(図示せず)が形成されることとなるので、得られる接合品の外観が悪くなるという問題が生じる。

【0012】この発明は、このような問題を解決するためになされたもので、周面に周方向の接合部を有する接合部材を接合する摩擦撹拌接合法において、プロープ引抜き後の孔や凹部を生じさせない摩擦撹拌接合法を提供することを目的とする。

#### 【0013】

【課題を解決するための手段】上記目的を達成するため、この発明は、周面に周方向の接合部を有する接合部材における前記接合部に、回転するプロープを挿入し、プロープとの接触部を摩擦熱にて軟化させ撹拌しながら、プロープを挿入状態で前記接合部に沿って相対的に移動させることにより、前記接合部材を接合する摩擦撹拌接合法において、前記接合部材の接合終端部に、該接合終端部における接合線の接線方向又はそれに近い方向に当て部材を当て、前記挿入状態のプロープを、接合終端部を通過させ当て部材へと移動させることを特徴とする。

【0014】これによれば、接合部材の接合終端部に、該接合終端部における接合線の接線方向又はそれに近い方向に当て部材を当てることにより、挿入状態のプロープを挿入状態のままで当て部材に移動させることができるようになる。そして、プロープが当て部材に進入すると、当て部材におけるプロープとの接触軟化部分が後方へと塑性流動して、プロープの通過後に生じる溝が埋められる。次いで、当て部材に移動した挿入状態のプロープを当て部材から引き抜く。こうすることにより、接合部にプロープ引抜き後の孔や凹部が残存しなくなり、そのため接合部の接合強度の低下を防止することができるし、接合部の強度的信頼性も向上する。その後、更に、当て部材を除去することにより、接合部材にプロープ引抜き後の孔や凹部が残存しなくなり、したがってプロープ引抜き後の孔や凹部により生じる接合品の外観体裁の低下を防止でき、そのため接合品の外観を維持することができるようになる。

#### 【0015】

【発明の実施の形態】次に、この発明の実施形態を図面に基いて説明する。

【0016】図1～図6は、この発明の一実施形態を示すものである。図1において、(1)(2)は、円形断面で所定長さを有する棒状のアルミニウム押出パイプ材からなる2個の接合部材である。これら接合部材(1)(2)は、互いに同形・同寸である。そして、これら接合部材(1)(2)は、端面同士を突き合わせる態様で

配置されている。この突合せ状態において、これら接合部材(1)(2)の軸線(P)(P)は一致しており、したがって一方の接合部材(1)の外周面と他方の接合部材(2)の外周面とは、面一となっている。

【0017】この実施形態は、上記従来技術と同じく、突合せ状態に配置した2個の接合部材(1)(2)を、突合せ部(3)の全周に亘って摩擦撹拌接合する場合を示すものである。したがって、突合せ部(3)が接合部材(1)(2)の接合部となり、接合部材(1)(2)の突合せ部(3)における周方向が接合線方向となる。そして、この摩擦撹拌接合により接合された接合品は、サスペンションアーム用部材、エンジンマウント用部材、スペースフレーム用部材等として用いられる。

【0018】(20)は接合工具であって、径大の円柱状回転子(21)の端部軸線上に径小のピン状プロープ(22)が突出して一体に設けられているもので、回転子(21)を高速回転させることによりプロープ(22)も高速回転するものとなされている。なお、プロープ(22)及び回転子(21)は、接合部材(1)(2)よりも硬質でかつ接合時に発生する摩擦熱に耐えうる耐熱材料によって形成されている。

【0019】(10)は、板状のアルミニウム製当て部材である。この当て部材(10)は、後述するように、接合部材(1)(2)の接合終端部にプロープ(22)の引抜き孔や凹部を残さなくするためのもので、接合終端部に、該接合終端部における接合線の接線方向に当てられるものであり、厚さ方向の片面をプロープ通過面(11)とし、長さ方向の一端面を接合部材との当接面(12)とするものである。前記プロープ通過面(11)は平坦面からなる一方、前記当接面(12)は接合部材(1)(2)の外周面に対応するように円弧状に湾曲した湾曲面からなる。そして、この当て部材(10)は、これを接合終端部(W2)に、該接合終端部における接合線の接線方向に当てたときに(図4(a)参照)、前記当接面(12)が接合部材(1)(2)の外周面に面接触状態に当接するとともに、前記プロープ通過面(11)が接合終端部(W2)における接合部材(1)(2)の外周面と面一となるものとなされている。

【0020】そして、この当て部材(10)は、ブロック状の金属製支持部材(13)によって安定良く支持されている。この支持部材(13)は、当て部材(10)とともに接合部材(1)(2)の外周面に当てられるものであり、その当接面(14)は、接合部材(1)(2)の外周面に対応するように円弧状に湾曲した湾曲面からなる。そして、この支持部材(13)は、前記当て部材(10)を接合終端部(W2)に当てたときに、前記当接面(14)が接合部材(1)(2)の外周面に面接触状態に当接するものとなされている。この発明に従う摩擦撹拌接合は次のようにして行う。即ち、前記接

合工具(20)の回転状態のプローブ(22)を、図1及び図2(a)に示すように、突合せ部(3)にその表面から挿入する。そして、図2(b)に示すように、プローブ挿入状態で、回転子(21)の先端の平坦状肩部(21a)を、接合部材(1)(2)の外周面に当接させるのが、接合開始時あるいは接合途中の軟化部分の素材の飛散を防止しえて均一な接合状態を実現し得るとともに、接合部材(1)(2)と肩部(21a)との摺動により摩擦熱を更に生ぜしめて、プローブとの接触部あるいはその近傍の軟化を促進し、更に接合部材(1)(2)の外周面の凹凸形成を防止する点から好ましい。

【0021】そして、プローブ挿入状態のまま、突合せ部(3)がプローブ(22)を順次通過するように接合部材(1)(2)をその軸線(P)を回転軸として回転させる。

【0022】プローブ(22)の回転により発生する摩擦熱、あるいは更に回転子(21)の肩部(21a)と接合部材(1)(2)の外周面との摺動に伴い発生する摩擦熱により、プローブ(22)との接触部分近傍において接合部材(1)(2)は軟化しかつ攪拌されるとともに、接合部材(1)(2)の回転に伴って、軟化攪拌部分がプローブ(22)の通過溝を埋めるように塑性流動したのち、摩擦熱を急速に失って冷却固化される。この現象が接合部材(1)(2)の回転に伴って順次繰り返されていき、図3(a)に示すように、突合せ部

(3)において両接合部材(1)(2)は一体化され順次接合されていく。なお、図3(a)において、(W)はこの摩擦攪拌接合によって形成された接合ビード部で、突合せ部(3)に沿って形成されている。また、(W1)は接合始端部である。

【0023】そして、接合始端部(W1)がプローブ(22)の挿入位置に戻ってきたとき、あるいは更に接合始端部(W1)がプローブ(22)の挿入位置を通過したとき、つまり接合部材(1)(2)が1回転以上、回転したとき、図3(b)に示すように、両接合部材(1)(2)は突合せ部(3)の全周に亘って接合されたこととなるので、接合終了となるが、このプローブ挿入位置でプローブ(22)を接合部材(1)(2)の外周面から引き抜くと、上記従来技術で説明したように、接合終端部(W2)にプローブの引抜き孔が生じてしま

う。

【0024】そこで、接合部材(1)(2)の回転を停止した後、支持部材(13)により支持された当て部材(10)を、図4(a)に示すように、接合終端部(W2)に、該接合終端部(W2)における接合線の接線方向に当てる。こうして当て部材(10)が接合終端部(W2)に当てられた状態において、当て部材(10)のプローブ通過面(11)は、接合終端部(W2)における接合部材(1)(2)の外周面と面一となっている。なお、図示していないが、接合部材(1)(2)が

1回転する前に、予め、当て部材(10)を当てておいても良い。

【0025】次いで、図4(b)に示すように、挿入状態のプローブ(22)を当て部材(10)に移動させる。このプローブの移動に際し、当て部材(10)のプローブ通過面(11)は、接合終端部(W2)における接合部材(1)(2)の外周面と面一となっているから、プローブ(22)を挿入状態のままスムーズに当て部材(10)に移動させることができる。

【0026】このようにしてプローブ(22)が当て部材(10)に進入すると、当て部材(10)におけるプローブ(22)との接触軟化部分が後方へと塑性流動して、プローブ(22)の通過後に生じる溝を埋め、従って接合部材(1)(2)の接合終端部(W2)に孔や凹部が残存することはない。

【0027】次いで、当て部材(10)に移動したプローブ(22)を、図5に示すように、当て部材(10)のプローブ通過面(11)から引き抜く。すると、当て部材(10)にプローブの引抜き孔(4)が形成されることとなるので、図6に示すように、この当て部材(10)を接合部材(1)(2)の外周面に沿って切断除去する。こうすることにより、接合部材(1)(2)におけるプローブ通過跡に孔や凹部が残存なくなり、そのため接合状態が良好な接合品を得ることができる。

【0028】なお、図示していないが、当て部材(10)に移動したプローブ(22)を当て部材(10)の端面から引き抜き、次いでこの当て部材(10)を除去しても良い。

【0029】また、接合部材(1)(2)の突合せ部(3)を接合する工程と、プローブ(22)を当て部材(10)に移動させる工程とを、別々に遂行しても良い。すなわち、例えば接合部材(1)(2)の突合せ部(3)を接合した後、プローブ(22)を接合部材(1)(2)から引き抜くことによって、接合終端部(W2)にプローブの引抜き孔(4)が形成されている接合品を、予め複数個、製作しておき、その後、接合品の接合終端部(W2)に当て部材(10)を当てるとともに、プローブ引抜き孔(4)にプローブを再度挿入して該プローブを当て部材(10)に移動させても良い。

【0030】なお、上述したように、当て部材(10)の材料の一部が接合部材(1)(2)における接合終端部のプローブ通過跡に充填されて接合部材の一部をなすものとなることから、当て部材(10)は接合部材(1)(2)と同一材料により製作されるのが望ましい。

【0031】図7は、上記実施形態の一変形例を示すものである。

【0032】この変形例は、複数個の接合部材の突合せ接合を連続して遂行する場合を示している。この摩擦攪拌接合法を説明すれば次の通りである。



【0033】すなわち、同図(i)に示すように、接合部材(1)(2)の突合せ部(3)に、上記実施形態と同様に、接合工具(20)のプロープ(22)を挿入する。そして、接合部材(1)(2)が1回転以上、回転して、該接合部材(1)(2)が突合せ部(3)の全周に亘って接合されたら、接合部材(1)(2)の回転を停止した後、当て部材(10)の一端部を接合終端部

(W2)に当てるとともに他端部を未接合状態の接合部材(1')(2')の突合せ部(3')に当てる。次いで、同図(ii)に示すように、挿入状態のプロープ(22)を当て部材(10)に移動させる。更にプロープ(22)を移動させて、同図(iii)に示すように、該プロープ(22)を未接合状態の接合部材(1')

(2')の突合せ部(3')に進入させる。次いで、当て部材(10)を未接合状態の接合部材(1')

(2')の外周面に沿って切断(切断部10a)した後、この未接合状態の接合部材(1')(2')の突合せ部(3')を、同図(i)に示すように、上記実施形態と同様に摩擦攪拌接合する。

【0034】こうすることにより、複数個の接合部材の突合せ接合を連続して遂行することができるようになり、したがってプロープ引抜き後の孔や凹部が残存していない、つまり接合状態の良好な接合品を効率良く得ることができる。

【0035】さらにこの発明は上記実施形態に限定されるものでない。

【0036】例えば、接合部材(1)(2)を回転させるのではなく、接合部材(1)(2)を固定しておき、プロープ(22)を接合部材(1)(2)の突合せ部(3)に沿って移動させても良い。

【0037】また、当て部材(10)を接合終端部(W2)に当てる方向は、接合終端部(W2)における接合線の接線方向に近い方向であっても良い。

【0038】もとより、接合部材(1)(2)は、アルミニウム以外の金属材からなるものであっても良いし、パイプ材である必要もなく、中実材であっても良い。

【0039】

【発明の効果】上述の次第で、この発明は、周面に周方向の接合部を有する接合部材における前記接合部に、回転するプロープを挿入し、プロープとの接触部を摩擦熱にて軟化させ攪拌しながら、プロープを挿入状態で前記接合部に沿って相対的に移動させることにより、前記接合部材を接合する摩擦攪拌接合法において、前記接合部材の接合終端部に、該接合終端部における接合線の接線方向又はそれに近い方向に当て部材を当て、前記挿入状態のプロープを、接合終端部を通過させ当て部材へと移動させることを特徴とするものであるから、この発明に係る摩擦攪拌接合法によれば、当て部材におけるプロ

ープとの接触軟化部分によってプロープの通過後に生じる溝を埋めことができる。したがって、周面に周方向の接合部を有する接合部材を摩擦攪拌接合によって接合する場合であっても、接合終端部にプロープ引抜き後の孔や凹部が残存しない、つまり接合部の接合強度が高くかつその強度的信頼性も高い接合品を得ることができる。さらに、当て部材からプロープを引き抜いた後、この当て部材を除去することにより、接合部材にプロープ引抜き後の孔や凹部が残存しない、つまり見栄えの良い接合品を得ることができる。

【図面の簡単な説明】

【図1】この発明の一実施形態を示す斜視図である。

【図2】同実施形態を示す図で、(a)は図1中のII-II線断面図、(b)はプロープを接合部材の突合せ部に挿入した状態の断面図である。

【図3】同実施形態を示す図で、(a)は接合部材の回転途中の状態の断面図、(b)は接合部材が1回転した状態の断面図である。

【図4】同実施形態を示す図で、(a)は当て部材を接合終端部に当てた状態の断面図、(b)はプロープを当て部材に移動させた状態の断面図である。

【図5】同実施形態を示す図で、(a)はプロープを当て部材に移動させた状態の斜視図、(b)はプロープを当て部材から引き抜いた状態の斜視図である。

【図6】同実施形態を示す図で、当て部材を接合部材から切り離した状態の斜視図である。

【図7】同実施形態の一変形例を示す図で、(i)は接合部材の回転途中の状態の断面図、(ii)はプロープを当て部材に移動させた状態の断面図、(iii)は当て部材を未接合の接合部材から切り離した状態の断面図である。

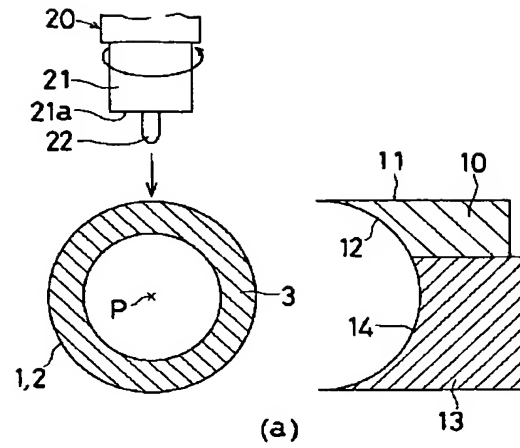
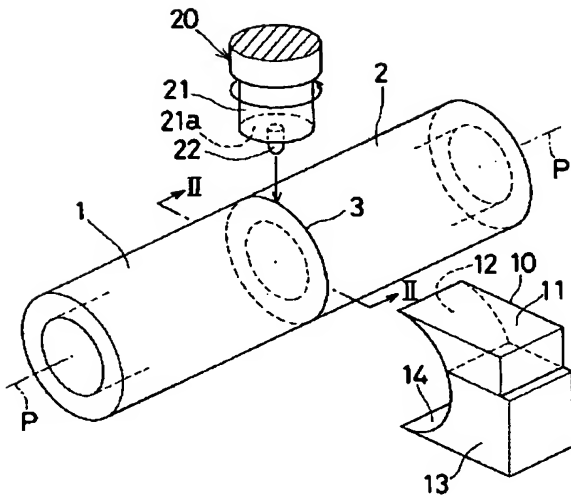
【図8】従来の摩擦攪拌接合を示す図で、(a)は接合部材の接合前の状態の斜視図、(b)は接合途中の状態の斜視図である。

【図9】従来の摩擦攪拌接合の欠点を示す図で、接合部材の接合後の状態の斜視図である。

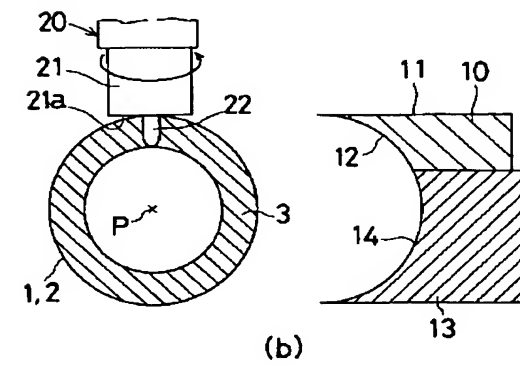
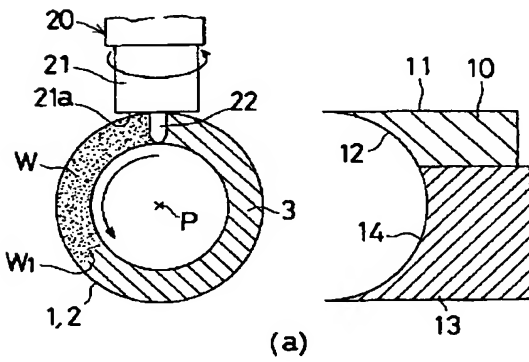
【符号の説明】

- 1、2…接合部材
- 3…突合せ部(接合部)
- 4…プロープ引抜き孔
- 10…当て部材
- 13…支持部材
- 20…接合工具
- 22…プロープ
- W…接合ビード部
- W1…接合始端部
- W2…接合終端部

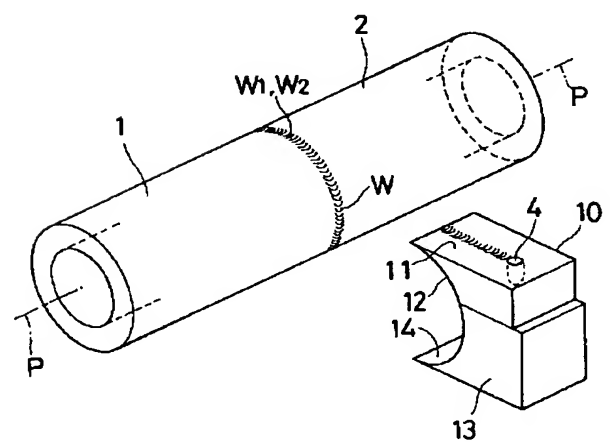
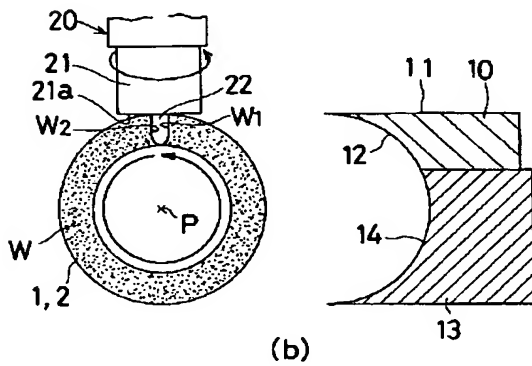
【図 2】



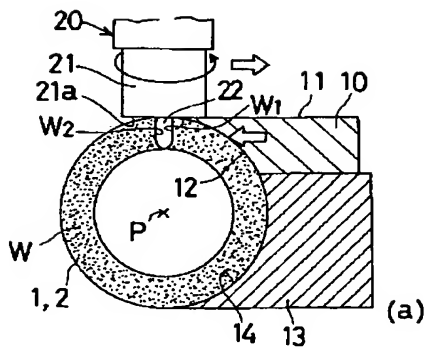
【図 3】



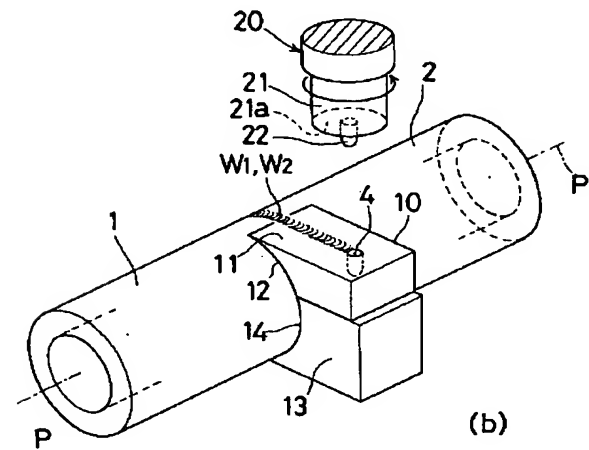
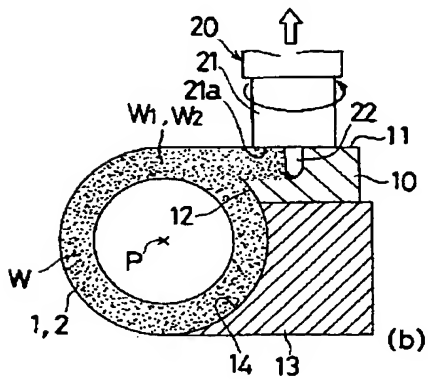
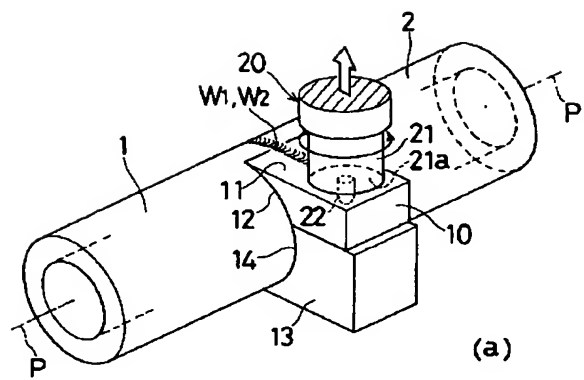
【図 6】



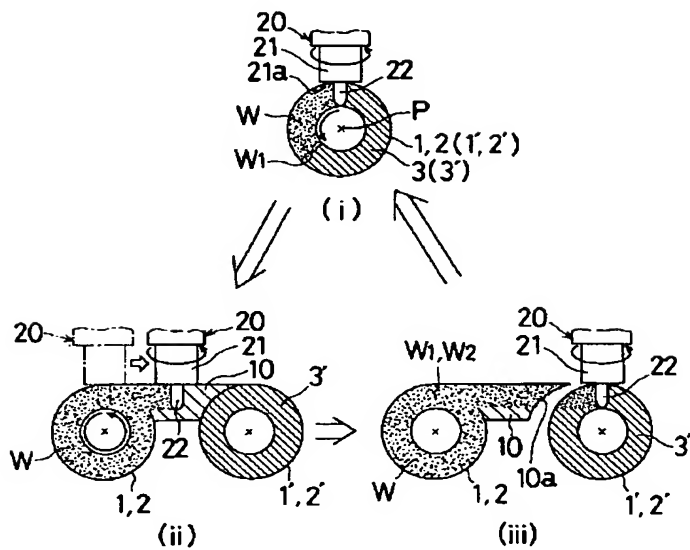
【図 4】



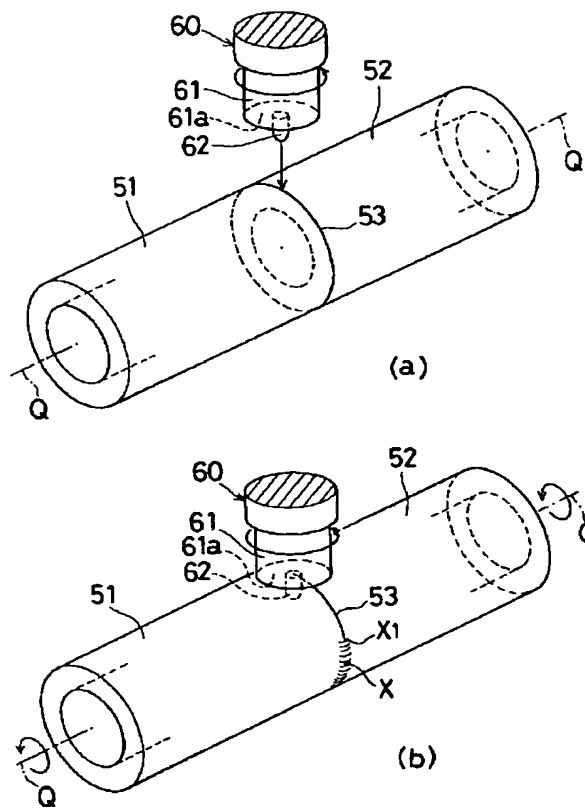
【図 5】



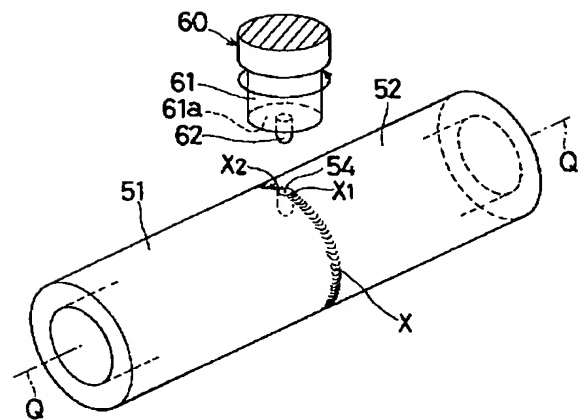
【図 7】



【図 8】



【図 9】



フロントページの続き

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